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THE DIAGNOSIS OF POLIOMYELITIS.

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The Meningitis Division of the Department of Health was established six years ago in order to afford to the physicians of the city of New York expert assistance in the diagnosis and treatment of meningitis. Since 1910 we have held consultations in over 1300 cases, presenting a great variety of meningeal conditions. These have included tuberculous meningitis, purulent meningitis of all kinds (meningococcic, pneumococcic, streptococcic, influenzal, staphylococcic); meningism in a variety of diseases, especially pneumonia and other acute infections in children; many rarer conditions, such as brain abscess, brain tumor, syringomyelia, etc.; and also about 70 cases of poliomyelitis occurring before the incidence of the present epidemic. When we add to them the number of frankly paralytic cases which were diagnosed by the attending physician without expert aid and the number of cases which we may reasonably assume escaped diagnosis altogether, we may arrive at some idea of the prevalence of poliomyelitis between the periods of epidemics.

It is evident that these rather numerous sporadic cases are dangerous foci of infection, and it is probably from such as these that our epidemics take their origin. They are the smouldering embers from which the sparks of conflagration may be disseminated at any time to inflammatory materials nearby. Those children born between the periods of epidemics are most susceptible to the disease; hence it is among these that the greatest morbidity occurs.

DISSEMINATION. Animal experimentation has conclusively demonstrated that the virus of poliomyelitis is discharged in the secretions of the nose, throat, and alimentary tract of patients suffering from the disease and in the secretions of the nose and throat of individuals in intimate contact with these patients.

In 1911 Kling, Petterson, and Wernstedt first succeeded in inoculating monkeys with the virus obtained in washings from the nose, throat, and alimentary tract of subjects who had died of poliomyelitis. Since then the experiment has been many times successfully repeated with washings obtained from living patients and also from their attendants. Dr. Zingher and the authors obtained washings from the nose and throat of an abortive case two weeks after the incidence of the sickness. With these we produced typical poliomyelitis in monkeys. In sections of the brain from one of these monkeys a few globoid bodies similar to those described by Flexner and Noguchi were found. A report of this work appeared in the *Jour. Am. Med. Assn.* for January 3, 1911.

Careful studies of epidemics in recent years have led to the conclusion that the mode of transmission of the disease is by actual personal contact rather than through intermediary means such as dust, flies, and insects. The Stomoxys calcitrans seems now to have been quite eliminated as a factor in the dissemination of poliomyelitis, though at one time much importance was attached to the part which this insect was thought to play in epidemics. It is conceivable that the common house fly may act as a passive carrier, as it does in typhoid fever; but its disease-bearing potentialities are strictly limited to this passive role.

Many important epidemiological studies have been made in recent years. One of the most interesting of these is that of Kling and Levaditi, who carefully investigated a small and definitely circumscribed epidemic occurring in 1911 on two little islands in the Bay of Stätboken, off the coast of Sweden. Because of the limited number of persons living on these islands, and the ease with which their movements could be followed, it was possible to trace clearly the probable transference of the virus from case to case. In this respect the report of this epidemic is unique.

A careful study of recent epidemics also brings out the fact that while, not uncommonly, two or more children of one family may be attacked simultaneously by poliomyelitis, it much more frequently happens that but one case will occur in a household consisting of several children of susceptible age, all of whom may have been equally exposed to the contagion. A similar phenomenon is seen in epidemic meningitis. It is only to be explained on the theory that those who escape possess a natural immunity to the virus of poliomyelitis. The number of susceptible children must also be proportionately small. We do not understand either the mechanism of this immunity or the reason for it. It has, however, been clearly demonstrated by means of the Schick test in the case of diphtheria infections, and analogy gives rational grounds for the belief that it also occurs in poliomyelitis.

Flexner has shown that the virus of this disease retains its virulence when subjected to high summer temperatures, to drying, or to the action of weak chemicals which destroy ordinary bacteria. It possesses, therefore, considerable resistance, and this fact should be borne in mind with every case. Bright sunlight readily destroys the germ.

To most of the laity, and to many physicians as well, poliomyelitis is known as a disease characterized by a frank, flaccid paralysis, its last stages being always mentally associated with the usual orthopedic brace. It may be well, therefore, to consider at this time those more atypical or abortive cases in which paralysis is transitory or entirely absent, because these, so usually unrecognized, are the most potentially dangerous.

In his monograph on acute poliomyelitis, Wickman presents the following classification of its varieties which is self-explanatory.

1. Spinal poliomyelitic form.
2. Form resembling Landry's paralysis.
3. The bulbar or pontine form.
4. Encephalitic type.
5. Ataxic type.
6. Polyneuritic type.
7. Meningitic type.
8. Abortive type.

While this classification is quite comprehensive it is perhaps somewhat complex for clinical use, and a simpler classification is that of Peabody, Draper, and Dochez, which presents three groups, namely:

1. Abortive types or non-paralytic (cases presenting no paralysis at any time).
2. Cerebral group (embracing involvements of the upper motor neuron with resulting spastic paralysis).
3. Bulbar spinal group (presenting lesions of the lower motor neuron with flaccid paralysis).

It is maintained by some authorities that poliomyelitis is a general infection and that symptoms of its effects on the central nervous system are entirely secondary in nature, when not absent altogether. It has even been suggested that paralytic cases may be in reality the atypical ones. Those holding this view would, in times of epidemics, diagnose as poliomyelitis cases presenting merely respiratory or gastro-intestinal symptoms, particularly if a case of frank paralysis exists in the same family at the time. When we consider the prevalence of gastro-intestinal disturbances in children, more especially during the summer season, such a conclusion is hardly tenable, unless corroborated by characteristic findings in the spinal fluid.

Personal experience inclines us to believe that these changes in the spinal fluid commonly accepted as diagnostic of poliomyelitis do not exist independently of some definite clinical manifestation of involvement of the central nervous system. It does not seem possible that a disease accompanied by an inflammatory reaction in the central nervous system and meninges of sufficient severity to produce changes in the spinal fluid could fail at the same time to afford definite clinical evidences of nervous involvement. Therefore, in the past, we have made it a rule to consider the possibility of poliomyelitis, and to perform lumbar puncture only in those cases presenting symptoms referable to the nervous system, such as hyperesthesia, Koenig's or the spinal sign, altered reflexes, stiffness of the neck, MacEwen's sign, etc. In the absence of these signs and in the presence of a normal clear spinal fluid we have always definitely excluded poliomyelitis.

When any of these signs are not present we have usually considered a lumbar puncture unjustifiable. In the few cases where we have performed it the fluids have been normal. The present epidemic may afford the opportunity to throw additional light upon the question by means of lumbar puncture in cases without meningeal symptoms, and also by means of animal inoculation.

INCUBATION PERIOD. The incubation period of poliomyelitis has not been definitely determined. It is considered by Wickman to be from one to four days and by Müller to be from five to ten days, averaging about a week. This corresponds to the incubation period of the disease as experimentally produced. Some observers, as Peabody, Draper, and Dochez, describe a true prodomal stage which they define as the period before the appearance of paralysis. As it is well known that many cases of poliomyelitis remain entirely free from all paralysis, it would seem unwise to date the incidence of the disease, even in the paralytic form, from the appearance of paralysis. We are, therefore, not justified in speaking of a true prodromal stage. There is, however, a type of onset described by Kling, Levaditi and others which we have also sometimes observed. In this the disease is ushered in by somewhat indefinite symptoms of an intestinal, coryzal, or anginal nature. A remission of from one to several days then occurs, to be followed by return of all symptoms and, usually, by an accompanying paralysis.

SYMPTOMS OF ONSET. The initial symptoms are much the same in all types of the disease and they may be quite as severe in the abortive as in the paralytic forms. While the onset may rarely be insidious, in the vast majority of cases it is very abrupt. Fever is probably the most constant, as well as usually the first, symptom. As a rule it is high and of comparatively short duration, falling by crisis or by lysis. Next to fever the most frequent symptom is a pronounced hyperesthesia or diffuse tenderness over the whole body. This is, perhaps, most marked in the legs and along the spine. There is also a decided drowsiness and the patient manifests great irritability when disturbed. Headache and vomiting are common. Constipation or diarrhea may be present, in our own experience, the former being more frequent. Retention of urine sometimes occurs, and this possibility should be constantly borne in mind. Convulsions, delirium, and spontaneous pains in the neck, back, joints, and limbs are other symptoms which may appear. Meningeal symptoms are very pronounced in a fairly large portion of cases. These are anteroposterior stiffness of the neck; Kernig's sign or the spinal sign of Peabody, Draper, and Dochez; MacEwen's sign, or change in the percussion note over the lateral ventricles due to distention with fluid. The reflexes may be exaggerated, but usually they are diminished or abolished. The pupillary reflex is, as a rule, retained. Following these symptoms paralysis may develop, most commonly appearing about the second day, though it may be delayed as late as the second week.

I. ABORTIVE OR NON-PARALYTIC TYPE. In the cases of the abortive type the above-mentioned symptoms may subside quickly —that is within a few days—without any evidence of paralysis or even of any weakness; or the paralysis or weakness may be transient only; or the condition may persist for two or three weeks, presenting a clinical picture which is most difficult to differentiate from tuberculous meningitis. But very often in these abortive cases all symptoms are much more indefinite than the above description would indicate. Therefore in the presence of an epidemic an unexplained temperature, especially if accompanied by general hyperesthesia, is sufficiently suspicious to warrant a lumbar puncture. This procedure not only assists materially in making a diagnosis, but practically always it markedly relieves the symptoms arising from meningeal irritation.

II. CEREBRAL TYPES (involving the upper motor neuron with spastic paralysis). Under this heading we may perhaps place those cases called polioencephalitic by Wickman. While, in our experience, examples of involvement of the upper motor neuron have not been uncommon, we have seen no single case presenting a spastic paralysis. In certain subjects with severe convulsions we have found the reflexes to be exaggerated, but evidences of spastic paralysis have been entirely wanting.

We have also occasionally found cases, somewhat resembling tuberculous meningitis, of a protracted duration, and presenting unmistakable symptoms of cerebral involvement, such as drowsiness, irritability, etc. But in these cases the reflexes have been sometimes diminished or lost instead of being exaggerated, as would be expected with cerebral irritation. Though realizing the difficulty of accurately classifying them, we have been in the habit of calling these polioencephalitic. We believe the true cerebral type of poliomyelitis to be exceedingly rare. No cases have fallen within our personal experience.

A very *unusual manifestation* of poliomyelitis is blindness. Our meningitis division has seen two such cases, one in the present epidemic. In the first case the vision was restored at the end of about three months. The second is a quite recent case and the blindness still persists.

III. Bulbospinal Type (with flaccid paralysis). Cases of this type are readily recognized. Therefore, they have long been considered as classical examples of poliomyelitis, and descriptions of them are found even in our older text-books. Hence they call for but little discussion here.

In the present epidemic a fairly large number of cases of this type have presented a rapidly ascending variety of paralysis, involving the muscles of respiration and ending with death. Some of these, when seen late, after pulmonary edema has developed, have been diagnosed as bronchopneumonia.

Examples of the bulbar type of paralysis, with difficulty in speaking and swallowing, are not uncommon in this epidemic. Some have, occasionally, been diagnosed as croup. Facial paralysis has also been quite common. As a rule it is not accompanied by the involvement of other muscles.

Differential Diagnosis. In the first twenty-four to forty-eight hours after its onset, poliomyelitis must be differentiated from the early stages of epidemic meningitis or mild purulent meningitis, and also from a meningism accompanying pneumonia or other infection. The clinical pictures presented by the above-mentioned diseases are quite similar, and it is in distinguishing between them that the examination of the spinal fluid affords us the most reliable information.

When seen a week or more after the onset, cases of poliomyelitis, especially if presenting cerebral symptoms, must be distinguished from tuberculous meningitis.

The procedure which we find to be our most reliable and valuable aid in the recognition of poliomyelitis is the examination of the spinal fluid. In poliomyelitis this fluid is usually clear. Very rarely it may be slightly cloudy in the early stages. It often shows a good fibrin web formation. The reduction of Fehling's solution is prompt. There is a slight or moderate increase of albumin and globulin and also of the cellular elements. As a rule, 80 per cent. or more of the cells are mononuclears. In examining such fluids we have frequently observed the presence of large mononuclear cells which we believe to be in a measure characteristic of poliomyelitis. Those poliomyelitic fluids which are cloudy present a polymorphonucleosis which may run as high as 90 per cent., but which we usually find to be about 60 per cent.

Two rare types of spinal fluids sometimes occur in poliomyelitis when the hemorrhagic process has been more than usually severe. The first of these is of the true hemorrhagic character, the red blood cells being evenly diffused throughout the field. When collected in successive tubes the specimens are all homogeneous, showing no change in the intensity of the hemorrhage. This serves to differentiate it from bloody fluids obtained by the accidental puncture of a vein.

Evidence of an older hemorrhage occurs in the second of these rarer fluids, which, having a characteristic yellow color and coagulating spontaneously, illustrates the so-called syndrome of Froin. These fluids occur in other conditions, and are therefore not pathognomonic of poliomyelitis.

In early cases of *purulent meningitis* the spinal fluid shows a varying degree of cloudiness, except in very rare instances, when it may be clear. A greater increase in albumin and globulin is usually found here than occurs in poliomyelitis, with a poorer reduction of Fehling's solution. The cells in these fluids of purulent meningitis are 90 per cent. or more polymorphonuclears, and the etiological organism is always found except in the mildest cases. In certain mild cases of meningitis—probably of the epidemic variety—the meningococci may never be positively demonstrated in the fluid. In purulent meningitis due to other organisms these practically always appear later. In one instance only we have seen a clear fluid from an early case of epidemic meningitis of about eighteen hours' standing. Although the cellular reaction was so slight the meningococcus was demonstrated to be present in the fluid by smear and culture.

The fluid in *meningism* is increased in amount, but is practically normal in character.

The fluid in *tuberculous meningitis* most nearly resembles that of poliomyelitis. It is practically always clear with a cellular increase consisting largely of mononuclears, though in very acute cases it may be distinctly cloudy with an excess of polymorphonuclears. The number of cells per cubic centimeter is usually greater than in poliomyelitis; the increase in albumin and globulin is more marked, and the reduction of Fehling's is not so good.

In rare instances when clinical signs are confusing and when the results of the cellular examination and chemical analysis are indefinite, and it is impossible to demonstrate the tubercle bacillus in the fluid, a positive diagnosis must wait upon the results of animal inoculation.

A detailed study of the spinal fluids of poliomyelitis examined at the Research Laboratory of the Department was made by Dr. H. L. Abramson, of the meningitis division. This was published in the *Am. Jour. Dis. Children,* November, 1915.

Another laboratory method of slight diagnostic value may be mentioned here, the so-called neutralization test. In this, serum from a suspected case in the stage of recovery is mixed with a known fatal dose of an active virus. These are incubated and later injected intracerebrally into monkeys. Failure of the disease to develop indicates that the virus has been neutralized. This test, however, does not furnish conclusive evidence of poliomyelitis, for sera from those known to have been free from a recent attack of the disease have sometimes successfully neutralized the poliomyelitic virus.

An exhaustive study of the blood picture was made by Peabody, Draper, and Dochez. It was shown that there existed a varying increase in leukocytes and a polymorphonucleosis. This is characteristic of so many other diseases that it affords little aid in diagnosis.

So far no specific treatment for poliomyelitis has been successfully developed. The intraspinal injection of the serum of convalescent patients has been tried, especially by Netter of Paris, but up to the present time no conclusive results have been obtained. In view of the rapidity with which the virus produces paralysis after the onset of symptoms, the possibility of a measure that will prevent its development seems too much to hope for. It has been suggested that the serum of convalescent patients may aid in the rapidity and extent of the recovery from the paralysis, though it would seem that after the very early stage the patient's own antibodies would far outnumber those in the sera of cases of some months or years' standing. It would seem, therefore, that the greatest hope of success in combating poliomyelitis lies perhaps in a prophylactic vaccination. Work is being done in this direction, and the present epidemic may be productive of results of value.